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Program and abstracts

Edited by Philippe STEEMANS & Philippe GERRIENNE

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"Micropaléontologie végétale et Palynologie (MVP)"

Palaeobiogeology, Palaeobotany, Palaeopalynology
University of Liège
October 23, 2015

Université de Liège

Program

09h30-09h55 - Welcome café

09h55-10h00 - **Philippe STEEMANS -** Some words…

10h00-10h20 - **Jean-Yves STORME & Emmanuelle J. JAVAUX -** Raman and FTIR microspectroscopy as a powerful tool for chemical characterization of fossil in Micropalaeontology and Palaeontology

10h20-10h40 - **Camille FRANÇOIS, Blaise KABAMBA BALUDIKAY, Jean-Yves STORME, Daniel BAUDET, Jean-Louis PAQUETTE & Emmanuelle J. JAVAUX -** Proterozoic time constraints on the deposit of the Mbuji-Mayi Supergroup, Democratic Republic of Congo (DRC).

10h40-11h00 - **Blaise KABAMBA BALUDIKAY, Jean-Yves STORME', Daniel BAUDET, Camille François & Emmanuelle J. JAVAUX -** Organic-walled microfossil assemblage and Chemostratigraphy of the Mbuji-Mayi Supergroup (Democratic Republic of Congo): Evidence for a Late Mesoproterozoic-Early Neoproterozoic age.

11h00-11h20 - **Jeremie BEGHIN, Simon W. POULTON, Nur GUENELI, Jochen J. BROCKS, Jean-Yves STORME, Christian BLANPIED & Emmanuelle J. JAVAUX -** Palaeoecological model of the Mesoproterozoic Taoudeni basin.

11h20-11h40 - **Yohan CORNET, Jean-Yves STORME, Philippe COMPÈRE, Nicolas J. BUTTERFIELD & Emmanuelle J. JAVAUX -** Ultrastructural and chemical characterization of the Cryogenian acritarch *Cerebrosphaera.*

11h40-12h00 - **Hendrik NOWAK, Thomas SERVAIS, Claude MONNET, Stewart G. MOLYNEUX & Thijs R. A. VANDENBROUCKE -** Phytoplankton dynamics from the Cambrian Explosion to the onset of the Great Ordovician Biodiversification Event: a review of Cambrian acritarch diversity

12h00-14h00 – Lunch

14h00-14h40 - KEYNOTE LECTURE: **Oive TINN, Philippe GERRIENNE, Leho AINSAAR, Viirika MASTIK, Tõnu PANI & Tõnu MEIDLA -** The Kalana *Lagerstätte*: puzzling biota among familiar fossils

14h40-15h00 - **Gerard J.M. VERSTEEGH, Borja CASCALES-MIÑANA, Philippe GERRIENNE, Emmanuelle J. JAVAUX, Thomas SERVAIS, Jean-Yves STORME & Oive TINN -** Lipid analysis on a putative early land plant and its matrix; Preliminary results.

15h00-15h20 - **Borja CASCALES-MIÑANA, Philippe STEEMANS & Philippe GERRIENNE -** An interesting Lower Devonian flora from the Iberian Peninsula

15h20-15h40 - Coffee break

15h40-16h00 - **Philippe GERRIENNE & Patricia G. GENSEL -** A growth model of *Armoricaphyton chateaupannense* Strullu-Derrien et al., a basal euphyllophyte with secondary growth from the Early Devonian of Montjean-sur-Loire (France)

16h00 – 16h20 - **Nicolas MOMONT & Philippe GERRIENNE -** Phylogenetical analysis of basal lignophytes : a preliminary approach

16h20 – 16h40 - **Cyrille PRESTIANNI, Robert GESS, Juan José RUSTÁN, Diego BALSEIRO, Emilio VACCARI & ANDREA F. Sterren -** Continental ecosystems at high palaeolatitude before and after the Devonian-Carboniferous boundary: two examples from South Africa and Argentina

16h40-17h00 - **Emile ROCHE, Chantal KABONY & Charles NTAGANDA -** Overview of vegetation dynamics on the Virunga Mountains, Rwanda, during the Holocene period

17h00 - Farewell café

Organic-walled microfossil assemblage and Chemostratigraphy of the Mbuji-Mayi Supergroup (Democratic Republic of Congo): Evidence for a Late Mesoproterozoic-Early Neoproterozoic age.

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The Mbuji-Mayi Supergroup is a sedimentary sequence in DRC unaffected by regional metamorphism (Raucq, 1957). It consists of two distinct successions: a lower, ~500 m thick siliciclastic sequence of the BI Group (dated at 1125 Ma (Cahen & Snelling, 1966) or between *ca.* 1175 Ma and 882 Ma (Delpomdor et al. (2013)) and an upper, ~1000 m thick carbonate sequence with stromatolitic build-ups and black shales of the BII Group directly overlain by basaltic lavas dated at 948 ± 20 Ma (Cahen et al., 1984). Five boreholes from Sankuru – Mbuji-Mayi region have been sampled in detail. A well preserved and diversified microfossil assemblage is reported including 54 taxa belonging to 32 genera. The typical late Mesoproterozoic - early Neoproterozoic acritarch, *Trachyhystricosphaera aimika,* is reported herein for the first time in central Africa, and co-occurs with other eukaryotes and prokaryotes. The available biostratigraphic data enable to suggest a minimum Tonian, pre-Sturtian age for the Mbuji-Mayi Supergroup. This age is consistent with the published and new geochronological data (François et al., 2015). Comparison with worldwide Proterozoic assemblages permits to define microfossil assemblages useful for biostratigraphy (Baludikay *et al.*, submitted). Moreover, $\delta^{13}C_{carb}$ positive and negative excursions in the BIe - BIIc interval are similar to variations in late Mesoproterozoic - early Neoproterozoic carbonate successions (Bartley & Kah 2004, Halverson et al. 2010)

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François, C., Baludikay, B.K., Storme, J.-Y., Baudet, D. & Javaux, E.J. (2015) Geochronological constraints on the diagenesis of the Mbuji-Mayi Supergroup, Democratic Republic of Congo (DRC). *Goldschmidt Abstracts*, 937

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Palaeoecological model of the Mesoproterozoic Taoudeni basin

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The mid-Proterozoic rock record preserves a relatively moderate diversity of early eukaryotes, despite the early evolution of fundamental features of the eukaryotic cell. Common hypotheses involve the redox state of stratified oceans with oxic shallow waters, euxinic mid-depth waters, and anoxic and ferruginous deep waters during this time period. Mid-Proterozoic eukaryotes would have found suitable ecological niches in estuarine, fluvio-deltaic and coastal shallow marine environments near nutrient sources, while N_2-fixing photoautotrophs bacteria would have been better competitors than eukaryotic algae in nutrient-poor niches.

Here, we present the first palaeoecological model of the late Mesoproterozoic Taoudeni basin, Mauritania, northwestern Africa. Sediments were deposited under shallow waters in pericratonic and epicratonic marine environments. Both microfossil assemblages and iron speciation were analyzed on the same samples, with the aim of better understanding the palaeoecology of early eukaryotes. Our study of the palaeobiodiversity shows the presence of prokaryotes and eukaryotes in the basin. Palaeoredox conditions rapidly fluctuated from anoxic to oxic states across the basin, but in terms of anoxic episodes, ferruginous conditions dominated in epicratonic environments, while euxinia was prevalent in pericratonic environments. A relatively higher fossil eukaryotic diversity, both in terms of richness and abundance, was observed in the more proximal environments during the marine transgression. Our results could possibly suggest that both the availability of molecular oxygen and nutrients are needed for a high eukaryotic diversity and could confirm a previous hypothesis suggesting that mid-Proterozoic eukaryotes would have found suitable ecological niches in shallow marine environments near nutrient sources.

An interesting Lower Devonian flora from the Iberian Peninsula

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To date, the known plant fossil record of the Lower Devonian in the Iberian Peninsula is mainly represented by poorly preserved remains with controversial taxonomic affinities, which do not allow a detailed study. However, advancing towards a comprehensive understanding of the Iberian plant fossil record is important because it contributes significantly to palaeogeographic interpretations due to the relative position of the Peninsula between Laurussia and Gondwana during Early Devonian times. So, thanks to several field campaigns conducted during the last years on the Lower Devonian outcrop of Mezquita de Loscos (Teruel Province, Spain), it has been possible to document five plant-bearing fossil sites with both plant megafossils and dispersed spores. Plant evidence comes from the Lochkovian-Pragian Nogueras Formation.

The plant megafossils have been interpreted as belonging to a basal euphyllophyte, to *Taeniocrada*-like remains and to *Hostinella* sp.; a paired elongated sporangia were also collected. In a first study, fourteen spore taxa were identified, including *Ambitisporites*, *Aneurospora*, *Brochotriletes*, *Chelinospora*, *Emphanisporites*, *Gneudnaspora* and *Retusotriletres*, among others.

This year, a new well-preserved palynoflora has been discovered which includes 35 spore species belonging to 21 genera, among which 15 are new for the locality, e.g., *Apiculiretusispora*, *Brochotriletes*, *Cirratriradites*, *Iberoespora*, *Knoxisporites* and *Verrucosisporites*. The assemblage is mainly composed of trilete spores. Interestingly, specimens of *Latosporites ovalis*, a species previously reported only from late Pragian-early Emsian of Saudi Arabia and Brazil, are found in this assemblage, and represent to date the earliest known occurrence of this species.

Latest advances on the study of the Lower Devonian flora include the discovery of a new plant with amazing morphology. This new plant, still under study, shows typical characters of Paratracheophyta, which suggests that the plant diversity of early floras from the Iberian Peninsula was more complex than originally documented. It also encourages further efforts on the area.

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Ultrastructural and chemical characterization of the Cryogenian acritarch *Cerebrosphaera*

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The late Tonian- early Cryogenian period is both a time of diversification and extinction of eukaryotes (Knoll *et al.,* 2006 ; Riedman *et al.,* 2014). Within this period of time the acritarchs *Cerebrosphaera* is a distinctive index taxon for pre-Sturtian succession (Grey *et al.*, 2011). This genus is characterized by dark robust walls ornamented by cerebroid folds. Two species were previously described based on the folds' width: *C. buickii* Butterfield *et al.* (1994) and *C. ananguae* Cotter (1999). To further characterize these acritarchs and determine their biological affinity, we analysed the ultrastructure and chemical composition of specimens from the 802±10 Ma Hussar and younger Kanpa Fm., Australia and from the ~820 Ma Svanbergfjellet Fm., Spitsbergen.

Two hundred and twenty one specimens were studied under light microscopy for the observation of morphological details and the estimation of the diversity of the population of vesicles. Fourteen specimens were studied under SEM for fine-scale morphological details. The combination of information showed that the two *Cerebrosphaera* species display a morphological continuum suggesting they are two extreme morphotypes of a single population. Ultrastructural analyses using TEM were performed on 11 Australian specimens and three specimens from Svalbard and revealed two complex wall ultrastructures: a three-layered wall ultrastructure a bi-layered wall ultrastructure. No ultrastructural feature explained the distinctive folding of the walls. Infrared and Raman micro-spectroscopy were performed on 22 specimens from Australia and two specimens from Svalbard to determine the chemical composition of the vesicles wall biopolymer and their thermal maturity. The wall biopolymer showed a highly aromatic composition with very short/highly branched aliphatic chains and a weak to medium thermal maturity unrelated to the opacity of the specimens. Comparisons were also made with leiospheres from the same samples.

The complex morphology, ultrastructure and chemistry, combined with its large size and recalcitrant composition indicate that *Cerebrosphaera* was a eukaryote, taking part of the eukaryotic diversification observed prior to the onset of Snowball Earth glaciations. In the same time, the absence of significant differences between the two species plead for a taxonomic revision of the two species, *C. buickii* being the senior species.

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Proterozoic time constraints on the deposit of the Mbuji-Mayi Supergroup, Democratic Republic of Congo (DRC)

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The Sankuru-Mbuji-Mayi-Lomami-Lovoy (SMLL) Basin, DRC, located between the Archean-Paleoproterozoic Kasai Craton and the Mesoproterozoic Kibaran Belt, includes the Mbuji-Mayi Supergroup. This sedimentary sequence is unaffected by regional metamorphism and preserves a large diversity of well-preserved acritarchs (organic-walled microfossils), evidencing the diversification of complex life (early eukaryotes) for the first time in mid-Proterozoic redox stratified oceans of Central Africa (Baludikay et al., 2015).

Lithostratigraphically, this Supergroup is composed of two distinct successions (i) a lower siliciclastic sequence of BI Group (*ca.* 1175 Myr to *ca.* 882 Myr (Delpomdor et al., 2013) or *ca.* 1050 Myr (Cahen et al., 1954 ; Holmes & Cahen, 1955)) unconformably overlying the *ca.* 3.0-2.6 Gyr granitoid Dibaya Complex to the North (Delhal et al., 1976); and (ii) a poorly constrained upper carbonate sequence with sparse shales of the BII Group. Basaltic pillow lavas overlying the Mbuji-Mayi Supergroup were dated around 950 Myr (Cahen et al., 1974 ; Cahen et al., 1984).

To better constraint the age of this Supergroup, we combine different geochronological methods, in particular on diagenetic minerals such as monazite (Montel et al., 1996, Rasmussen & Muhling, 2007) and xenotime (McNaughton et al., 1999) but also on zircon. For the BI Group, results of *in situ* U-Pb datings with LA-ICP-MS on monazite, xenotime and zircon (Laboratoire Magmas et Volcans, Clermont-Ferrand) provide ages between 2.9 and 1.2 Gyr for zircons and between 1.4 and 1.03 Gyr for monazites and xenotimes. Preliminary results of *in situ* U-Th-Pb datings of well-crystallized diagenetic monazites with Electron MicroProbe (*Camparis, UPMC, Paris*), highlight that some monazites display zonations with an inherited core around 1155 Myr and diagenetic rims around 1075 Myr. This provides that the diagenesis of BI Group is younger than 1175 Myr (Delpomdor et al., 2013) and probably around 1050-1075 Myr (age on syngenetic galenas (Cahen et al., 1954 ; Holmes & Cahen, 1955), and ages obtain on monazite rims in this study).

Sm-Nd datings on basaltic pillow lavas overlying the Mbuji-Mayi Supergroup (previously dated around 950 Myr (Cahen et al., 1974; Cahen et al., 1984)) are in progress (Collaboration: V. Debaille, Laboratoire G-Time, ULB, Bruxelles) to precisely limit in time the end of diagenesis in this Supergroup.

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A growth model of *Armoricaphyton chateaupannense* Strullu-Derrien et al., a basal euphyllophyte with secondary growth from the Early Devonian of Montjean-sur-Loire (France)

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Armoricaphyton chateaupannese Strullu-Derrien et al., 2014, an Early Devonian (Pragian) basal euphyllophyte was first presented as the earliest plant with wood (Gerrienne et al., 2011; Strullu-Derrien et al., 2013) and then briefly described, named and assessed in regard to hydraulic conductance of the secondary xylem (Strullu-Derrien et al., 2014). In the study, we provide a growth model for the plant.

We studied several individual axes preserved by pyrite. No fertile remains were obtained. Pyritized axes were sectioned transversely or longitudinally. Exposed surfaces were etched in nitric acid, following the technique for enhancing contrast in pyrite petrifactions described by Kenrick (1999) and studied by the acetate peel technique (Galtier and Phillips, 1999).

The primary xylem strand is centrarch and includes P-type tracheids. The pattern of lateral branch departure was studied based on serial peels. The secondary xylem of the plant is illustrated in transverse, radial and tangential longitudinal sections. The proportion of the primary vs secondary xylem varies considerably among the different specimens studied. The secondary xylem includes P-type tracheids with similar pitting in radial and tangential walls. The presence of one-walled spaces interpreted as rays is confirmed. This study also documents the earliest occurrence of secondary xylem at base of next higher order of branches. We used the pattern of lateral branch departure as well as the variation of primary vs secondary xylem proportion to reconstruct a plausible growth model of this unusual Early Devonian plant (Figure 1), with documented epidogenetic, menetogenetic and possible apoxogenetic phases of growth of primary tissues.

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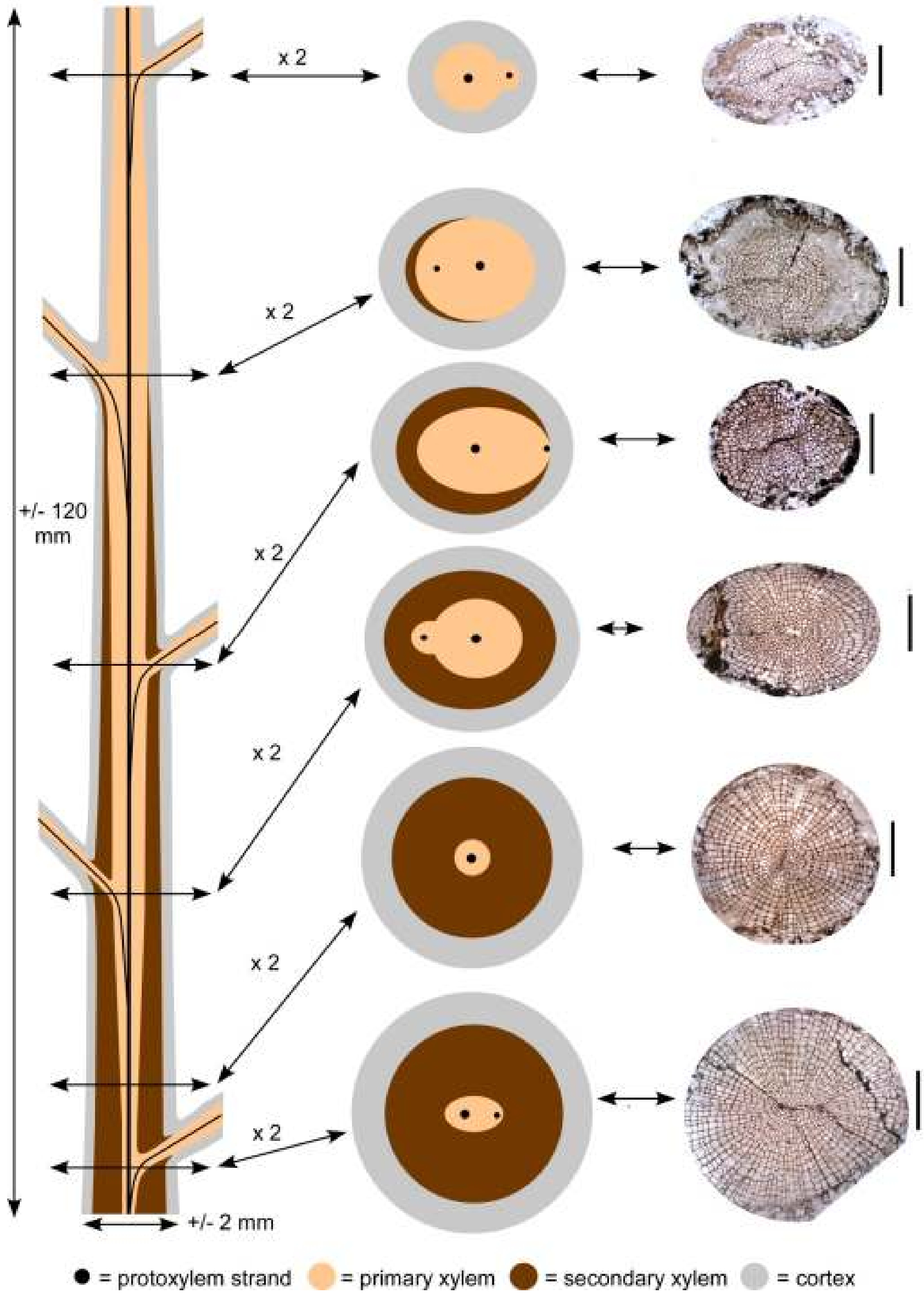

Figure 1. Suggested schematic reconstruction of the growth pattern of *Armoricaphyton* showing the variation in size of the primary xylem strand and the thickness of the secondary xylem ring, from proximal to distal regions of the plant. Scale bar = 500 µm.

Phylogenetical analysis of basal lignophytes: a preliminary approach

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Lignophytes comprise the Stenokoleales, the paraphyletic progymnosperms (Aneurophytales, Archaeopteridales and Protopytiales) and the spermatophytes (Kenrick and Crane, 1997). Progymnosperms are characterized by reproductive and vegetative organs of apparent pteridophytic affinities and a gymnospermous anatomy (Beck, 1960). All the current phylogenies indicate that the progymnosperms are a paraphyletic group at the base of the lignophytes tree (Crane, 1985; Doyle and Donoghue, 1986; Rothwell and Serbet, 1994; Hilton and Bateman, 2006; Meyer-Berthaud and Decombeix, 2007). In these analyses, Archaeopteridales are considered the sister group of the spermatophytes. These analyses suggest a monophyletic origin of the seed plants. However, the hypothesis has never been truly tested. Indeed, all the phylogenetic analyses of the spermatophytes use no more than three progymnosperm genera, usually as outgroup (Mathews, 2009). In addition, all of those analyses never take the Stenokoleales into account. Current phylogenies do not take into account the full diversity of the Aneurophytales and Stenokoleales. The lack of knowledge about these basal euphyllophytes and lignophytes is an obstacle in the inclusion of these plants into phylogenies.

We propose a simple cladistic analysis to test the affinities of some basal euphyllophytes including the Aneurophytales and the Stenokoleales. The cladistic analysis is attempted on the basis of a matrix containing mostly morphological and anatomical characters of the vegetative lateral branching systems.

The objective of this analysis is not to test the monophyly of the Aneurophytales or the different hypotheses about the origin of the seed plants. It rather aims at observing the position of the tested Aneurophytales and Stenokoleales on the basis of some characters that have been found important while studying both orders. The results of this analysis are discussed.

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Phytoplankton dynamics from the Cambrian Explosion to the onset of the Great Ordovician Biodiversification Event: a review of Cambrian acritarch diversity

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Most early Palaeozoic acritarchs are thought to represent a part of the marine phytoplankton and so constituted a significant element at the base of the marine trophic chain during the 'Cambrian Explosion' and the subsequent 'Great Ordovician Biodiversification Event.' Cambrian acritarch occurrences have been recorded in a great number of studies. In this paper, published data on Cambrian acritarchs are assembled in order to reconstruct taxonomic diversity trends that can be compared with the biodiversity of marine invertebrates. We compile a database and calculate various diversity indices at global and regional (i.e. Gondwana or Baltica) scales. The stratigraphic bins applied are at the level of the ten Cambrian stages, or of fourteen commonly used biozones in a somewhat higher resolved scheme.

Our results show marked differences between palaeogeographical regions. They also indicate limitations of the data and a potential sampling bias, as the taxonomic diversity indices of species are significantly correlated with the number of studies per stratigraphic bin. The total and normalized diversities of genera are not affected in the same way. The normalized genus diversity curves show a slow but irregular rise over the course of the Cambrian. These also are the least biased. A radiation of species and to a lesser extent of genera in the 'lower' Cambrian Series 2 appears to mirror the 'Cambrian Explosion' of metazoans. This radiation, not evident on Gondwana, is followed by a prominent low in species diversity in the upper Series 3 and lower Furongian. Highest diversities are reached globally, and on both Baltica and Gondwana, in the uppermost Cambrian Stage 10, more precisely in the *Peltura* trilobite Zone, preceding a substantial phase of acritarch species extinction below and at the Cambrian/Ordovician boundary. Nearly all the genera present in Stage 10 survived into the Ordovician. The forms that emerged during the Cambrian therefore became the foundation for the more rapid radiation of acritarchs during the 'Great Ordovician Biodiversification Event'.

Continental ecosystems at high palaeolatitude before and after the Devonian–Carboniferous boundary: two examples from South Africa and Argentina

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The terrestrialization of living forms is by far one of the most important process that took place during the Palaeozoic. It deeply modified all ecosystems, both marine and continental. Characterized by an unprecedented increase of the biodiversity and of the biomass on emerged lands, it is also marked, at the end of the Devonian period by severe crisis in marine ecosystems as well as by climatic instability. We here report two assemblages situated at both sides of the Devonian–Carboniferous boundary. The first has been collected by R.G. in the Waterloo Farm locality (South Africa) and is latest Famennian in age. The second comes from the Tournaisian part of the Sierra de las Minitas (Argentina).

The purpose of this communication is to compare two particularly different environmental settings documenting the changes that occurred globally at the Devonian–Carboniferous boundary. The Waterloo Farm locality represents a lagoonal system partially separated from the Agulhas Sea by a barrier island complex (Gess & Hiller, 1995). Fine black anaerobic muds deposited in still portions of the lagoon accumulated a huge mixed assemblage representing the life of marine and fresh water influenced parts of the lagoonal system, as well as that of adjacent terrestrial environments. Terrestrial remains largely consist of plant material comprising a minimum of fifteen taxa. These represent most major Late Devonian groups including zosterophyllopsids, trimerophytes, sphenophytes, herbaceous and arborescent lycopdsids, iridopterids and progymnosperms. This locality provides a unique holistic picture of high latitude continental life in Gondwana immediately predating the End Devonian Extinction event. The here reported Sierra de la Minitas deposits consist in fine to medium grained fossiliferous sandstones deposited in a marine environment (Prestianni *et al.*, 2015). Fossils from this interval include brachiopods, bivalves, crinoids, orthoconic nautiloids, gastropods, scarce fish remains and plants. The plant assemblage reveal a low diversity flora dominated by herbaceous lycopsids but also present traces of ferns and seed plants. Tournaisian Gondwanan plant communities from high latitudes are interpreted as being more complex than previously thought. Their discovery in a sedimentary environment associated with glacigenic deposits, shows that this new record might be linked to the coeval glacial age widely recorded elsewhere in Gondwana.

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Overview of vegetation dynamics on the Virunga Mountains, Rwanda, during the Holocene period

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Douze mille ans d'histoire de la végétation afro-montagnarde, au nord du Rwanda, ont pu être retracés sur base de l'étude palynologique de deux séquences sédimentaires prélevées, l'une dans la tourbière de KIGUHU, l'autre dans le marais de KARISOKE situés respectivement à 1800 m et à 3030 m d'altitude sur la chaîne volcanique des Virunga.

Au début de la période qui correspond à la fin du Tardiglaciare, un climat froid et relativement humide se traduit par une extension des landes et des pelouses montagnardes et par des savanes à basse altitude.

L'Optimum Humide Holocène (9000-6000 ans BP), voit se développer une progression sensible de la forêt dense afro-montagnarde concomitante d'un important épisode lacustre.

Vers 4000 ans BP, une expansion importante des milieux ouverts herbacés naturels « climatiques », souligne un déficit hydrique à mettre en relation avec la période d'aridité globale de l'Afrique à cette époque. Par la suite, les variations observées au sein de la forêt afro-montagnarde évoquent une instabilité climatique qui perdure jusqu'à 2000 ans BP.

Au cours du premier millénaire AD, un regain forestier se manifeste, brièvement interrompu par une pulsation sèche vers 500 AD. Dès le début du second millénaire AD, l'influence anthropique commence à faire sentir ses effets ; son intensité croissante au cours du temps laissera des traces de secondarisation durables.

Palynological studies of peatbogs located in the Virunga volcanoes area, in northern Rwanda, revealed important environmental events that occurred during the last 12000 years.

At the end of Upper Pleistocene, an expansion of open woodlands and grasslands results from a cold and rather wet climate.

During the humid and warm Holocene Period (9000-6000 years BP), an important increase of the afro-mountainous rain forest is recorded, simultaneous of lake levels rise.

Around 4000 yrs BP, spreading of grasslands testifies that an aridity peak occurred at that time. Perturbations in the forest till 2000 years BP suggest the persistence of a climatic instability.

In the course of the first millennium AD, the rainforest grew again, that event being shortly interrupted by a drought around 500 years AD. At the beginning of the second millennium AD, began the human impact on the environment that increased progressively till today.

Raman and FTIR microspectroscopy as a powerful tool for chemical characterization of fossil in Micropalaeontology and Palaeontology

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Raman and Fourier Transform InfraRed microspectroscopy are non-destructive spectroscopic techniques which used the molecular vibrations induced by the interaction of light with the matter. These two complementary techniques are widely used for chemical characterization of different kind of material (organic and inorganic) in different disciplines. Today, these two vibrational spectroscopic techniques show an increasing interest in micropalaeontology and palaeontology, especially to elucidate the chemical composition and preservational mechanisms of fossil material. Acritarchs, scolecodonts, conodonts, fossil algae, fossil plants, stromatolites, fossil palynomorphs, dinosaur material (e.g. bones, feather) are some examples of fossil material already chemically constrained by Raman or FTIR spectroscopy. In the Pal³Lab of the Geology department of the University of Liège supported by the ERC ELiTE project, these two techniques are developed to constrain the biogenicity and biological affinities of Precambrian fossil material by comparison with the chemical composition of modern organisms, on isolated specimens or in situ in thin section. We also use these techniques for identifying minerals, and the spatial distribution of minerals and organics, and to build a reference database on mineral and organics. In our Lab, Raman analyses are performed with a Renishaw *In via* Raman spectrometer coupled to a Leica DM 2500 confocal microscope and with 514.5 nm, 633 nm or 785 nm as laser sources. Acquisitions are obtained with a 1200 or 1800 grooves/mm grating with an air cooled (-70°C) 1024x256 pixel CCD array detector. This method enables a 2000 cm^{-1} spectral detection range. Static point and high resolution dynamic line-scanning Raman technique (Renishaw HR StreamLine mode) in 2D or 3D are available for chemical mapping of the material under study. Micro FTIR spectra are recorded in the 4000-400 cm^{-1} range (mid-infrared) with the co-addition of 128-512 scans at a spectral resolution of 4cm^{-1} using a Bruker Tensor 27. The spectrometer is coupled to a Bruker Hyperion II microscope equipped with a (15x, 36x, ATR) objective. In this talk, example of ongoing studies will be presented.

The Kalana *Lagerstätte*: puzzling biota among familiar fossils

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The early Silurian *Lagerstätte* in central Estonia, near the village of Kalana, offers an impressive view into a shallow water marine ecosystem of those days. The operating quarry has opened limestone and dolomite succession of early Aeronian (Llandovery, Silurian) age, in local stratigraphy known as the Raikküla regional stage. Biostratigraphically, the Raikküla Stage correlates with the *Aspelundia* Superzone (Männik, 2007), the layers with exceptionally preserved fossils belong to *Pranognathus tenuis* conodont zone (Ainsaar *et al.*, 2014**)**.

The studied algal flora in Kalana shows considerably higher diversity than has been previously documented in the whole Lower Palaeozoic strata. The most abundant algal species in Kalana is *Leveilleites hartnageli* (Figure 1), interpreted as a red alga (Tinn *et al.*, 2009). The most diverse flora is made up of different dasycladaceans, an extant group of unicellular tropical to subtropical shallow water marine green algae, with a long and highly diverse fossil record that is dominated by calcareous forms. The dasyclads recorded in Kalana - *Palaeocymopolia silurica* (Mastik and Tinn, 2015), *Kalania pusilla* (Tinn *et al.*, 2015), *Medusaegraptus mirabilis*, *Chaetocladus* sp. and *Inopinatella* sp. -, however, do not show any signs of calcification.

The invertebrate fauna, although not especially diverse, is largely normal marine fauna. Most abundant brachiopod (e.g. *Trimerellidea* sp., *Eostropheodonta* sp., *Koigia extenuata*, *Zygospira aspirinis*, *Hindella crassa*, *Coolinia applanata*) and gastropod (e.g. *Murchisonia* sp.) fauna can be found in storm accumulated coquina lenses. Among arthropods, fragments of phacopid and lichid trilobites have been documented, the upper part of the section reveals also shallow lagoonal lenses with leperditids and rare eurypterids. Besides, tabulate and rugose corals, orthocone and coiled cephalopods, sponges, graptolites, ostracods and scolecodonts have been recorded. In addition to invertebrates, a complete head-shield of an osteostracan proves the presence of vertebrates in the ecosystem.

While most of the aforementioned fauna has been preserved in its classical form as skeletal fossils, the locality has also yielded soft-bodied animals (e.g. annelids and a flatworm) and skeletal fossils with soft parts, like for instance beautifully preserved complete rhodocrinitid (?) crinoids with finest pinnules attached to brachials.

Perhaps the most interesting, and the most important from the evolutionary point of view, are some enigmatic fossils which are not easily assignable to any previously described taxa. Many of these puzzling fossils show detailed anatomy with exquisite micron-scale preservation, which, however, does not make the determination easier and different detailed studies are required to understand their true biological nature.

Although the first algal fossils in Kalana were found in 2006, rare remains of organic fossils were noticed by palaeontologists already in the last century at the same stratigraphical level in several core sections (Nestor *et al.*, 2003). Besides, several other quarries in central Estonia have revealed occasional algal fossils, showing that the distribution of the exceptionally preserved biota occupies considerably larger area than exposed by the Kalana quarry only.

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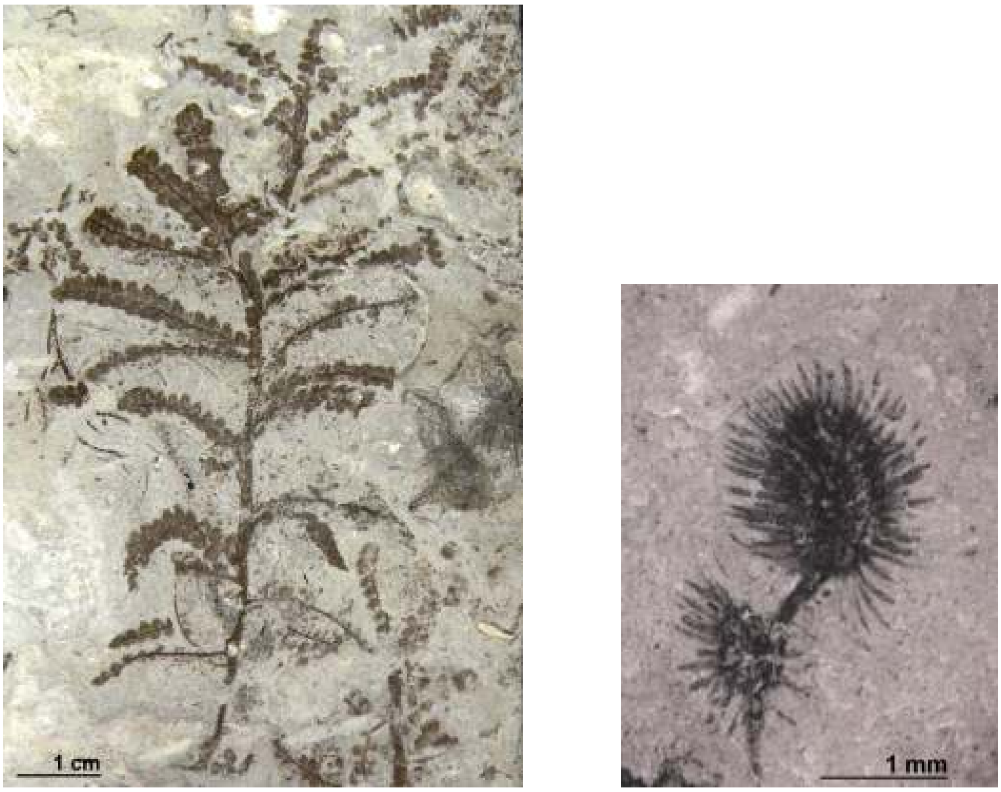

Figure 1. *Leveilleites hartnageli*, interpreted as a red alga. Left: gross view of one large specimen; right: putative fertile part.